09/314 001

METHOD AND APPARATUS FOR PRODUCING BASALTIC FIBERS

Field of the invention

The present invention relates to a method and apparatus for manufacturing mineral fibers from natural materials of the basalt group (basalts, andesitobasalts, andesites, gabbro etc.) which can be used in the construction, textile and chemical industries.

Reference to Related Application

This is a continuation of International Application PCT/RU97/00355 filed under the Patent Cooperation Treaty on November 18, 1997, the entirety of which is incorporated by reference into this specification.

Background of the Invention

There are three main types of rock composition of the basalt group. The first type: rock composition enriched with oxides of iron and titanium (~70% of Fe_2O_3 and 20% of TiO_2). The second type: basalt rocks enriched with oxides of aluminum and silicon (~±25% of Al_2O_3 and 55% of SiO_2). The third type: basalt rocks enriched with oxides of magnesium, calcium and iron (~12% of MgO, 20% of CaO, 10% of Fe_2O_3).

All these compositions are intended for basaltic fiber manufacture. However, to obtain temperature and chemical resistant fiber of high quality, the basalt rock composition is limited by the content of oxides. For example, in order to produce basaltic fibers, a glass is known containing the oxides $Si0_2$, Al_2O_3, Fe_2O_3, TiO_2 FeO, MnO, CaO, MgO, K_2O, Na_2O, SO_3, P_2O_5, Se_2O_3, ZnO with the relations of constituents $Al_2O_3/CaO+MgO < 2.0$, ensuring increased acid

resistance and temperature range of manufacture (Russian patent 2039019, class CO3C13/02, 1995).

However the known composition of glass makes it possible to obtain high content of $A1_2O_3$ only in the specified range. This limits the use of basalts of other types and with other relations of oxides, and it eliminates the possibility of manufacturing from them a good acid and alkali resistant fiber of high heat stability.

The fiber manufacture from a glass mass of each individual composition requires certain production know-how. The closest method to the proposed one in its technical essence and the obtained result is a method for producing basaltic fibers which includes charging, melting of basalt in the interior of a furnace, feeding the melt into a feeder and stabilizing the glass mass, manufacture of fiber through a feeding unit, pulling the fiber through spinnerets, oiling the fiber, and reeling the fiber onto bobbins (Russian patent 2039715, class CO3B37/02, 1995).

The closest device to the proposed one is a device for producing basaltic fibers which includes a basalt weigher, a melting furnace, a feeder with discharging devices, feeding units, spinnerets, mechanisms for applying oil, and mechanisms for reeling the fibers up onto bobbins (Russian patent 2039715, class C03B37/02,1995).

Disadvantages of the known method and device are: not very high quality of the fiber at a low percent of manufacture, the complexity of the production process because of the necessity of the preparation of basalt rock, the necessity of a high temperature range in the melting furnace, and a long cycle of glass mass stabilization that involves the possibility of its crystallization and hence the vitrification on the surface of spinnerets.

Summary of the Invention

An object of the invention is to provide a method and a device for obtaining corrosion resistant, heat stable continuous fibers out of basalt rocks of numerous compositions and to simplify the technology and the apparatus for manufacturing such fibers.

The technical result of the realization of the proposed method and device is to widen the technical possibilities of using basalt rocks of a wide range with a reduced process cycle, to increase the stability of the process, and to improve the strength, corrosion resistance and heat stability of the fiber.

The technical result is obtained in a method for producing basaltic fibers which includes the steps of preheating the basalt, charging the preheated basalt into a melting furnace, melting the basalt to form a glass mass, keeping the melted glass mass in a stabilizing section of the melting furnace until it reaches the fiber manufacture temperature, further stabilizing the glass mass in a feeder, pulling the fiber from spinnerets, oiling the fiber, and reeling it up onto bobbins. Stabilization in the feeder is carried out to obtain a glass mass composition with the relation of basic constituents

$$\frac{Al_2O_3 + SiO_2}{CaO + MgO} \geq 3 \qquad \frac{FeO}{Fe_2O_3} \geq 0.5$$

$$\frac{2Al_2O_3 + SiO2}{2\,Fe_20_3 + FeO + CaO + MgO + K_2O + Na_2O} > 0.5.$$

The technical result is best attained when:

- before charging into the furnace, the basalt is heated to 150 - 900^{0}C;
- the fiber manufacture temperature is maintained equal to t^{melt} +(50 - 250°C) where t^{melt} is

a temperature range of basalt melting;

- stabilizing of the glass mass in the feeder is carried out at a temperature of 1250 - 1450°C.

AF3

The technical result is obtained in a device for producing basaltic fibers, which includes a basalt weigher, a melting furnace, a feeder with discharging devices, feeding units, spinnerets, mechanisms for applying oil, and mechanisms for reeling the fibers up onto bobbins. According to the invention, a heat exchanger connects the basalt weigher with a firing space of the melting furnace, and the melting furnace has a stabilizing section for stabilizing the melted glass mass. The stabilizing section is connected with the feeder. The best technical result is attained when the height of the stabilizing section is 0.4 - 0.6 of the height of the inner space of the furnace. A heat exchanger preliminarily heats the basalt before it is charged into the furnace. The glass mass is stabilized to obtain glass mass composition with the relation of basic constituents

$$\frac{Al_2O_3 + SiO_2}{CaO + MgO} \geq 3 \qquad \frac{FeO}{Fe_2O_3} \geq 0.5$$

$$\frac{2Al_2O_3 + SiO2}{2\,Fe_20_3 + FeO + CaO + MgO + K_2O + Na_2O} > 0.5,$$

making it possible to remove crystal water, gas bubbles and foam, to stabilize the volume of the glass mass to obtain an even and smooth surface, and to ensure the stability of the temperature range and viscosity which is essential for fiber manufacture. The presence of a heat exchanger in the weigher on simultaneous charging ensures uniform heating throughout the volume of basalt by the reduction of hot air flowing from the firing space of the melting furnace, enabling the utilization of waste gases and the reduction of fuel consumption. The stabilizing section which has a height of 0.4 - 0.6 of the height of the furnace interior space contributes to stabilizing the melt in volume at the furnace exit with a specified temperature. The stabilizing section height is delw

Not required ?

definition determined by the melt height as the temperature decreases, and the possible exit of gases and stabilizing foam.

The invention utilizes new combinations of technical features which satisfy the "novelty" and "inventive step"criteria. The utilization of the invention serves to increase the productivity of the melting furnace, and simultaneously decrease fuel and power consumption. This fact establishes that the proposed method and device satisfy the "industrial applicability"criterion.

Brief Description of the Drawings

Fig. 1 illustrates an apparatus for producing basaltic fibers, using the process of the invention.

Detailed Description

The apparatus is a plant, which has a weigher 1 for basalt 2 charging and a heat exchanger 3, connected with a firing space 4 of the melting furnace 5. The melting furnace 5 has a stabilizing section 6 in which the melted glass mass becomes stable in volume when reaching the temperature of fiber manufacture. The melting furnace 5 and stabilizing section 6 have heating systems 7. The stabilizing section 6 of the melting furnace 5 is connected to a feeder 8 where the melt becomes stable ~~till~~ by way of averaging the mass and ensuring the relation of constituents in the composition. The feeder 8 has discharging devices 9 and feeding units 10 delivering the melt into spinnerets 11 through which the basaltic fibers 12 are pulled. Then the fibers 12 are supplied to oiling mechanisms 13 and mechanisms 14 for reeling the fibers onto bobbins.

The basalt compositions used in practicing the invention are given in Tables 1-4.

According to the method, basalt rocks are first cleansed of impurities, powdered, and

delivered through the weigher 1 into the melting furnace 5. The weigher 1 is connected with a heat exchanger 3 where basalts 2 are heated to a temperature 150 - 900 °C by hot air coming from the firing space 4 of the furnace 5. The heated basalts 2 enter the melting furnace 5 where they melt at a temperature of 1450 °C $\pm$ 50 °C until a glass mass melt is formed. Then the glass mass melt enters the stabilizing section 6 of the melting furnace 5. The limited height of the stabilizing section 6 ensures the stabilization and temperature reduction to a temperature of fiber manufactures which is t^{melt} + (50 - 250 °C). In the stabilizing section 6, gas bubbles and foam are expelled and the surface becomes smooth and even. The melting furnace 5 and its stabilizing section 6 have heating systems 7. Out of the stabilizing section 6, a partially stabilized melt of glass mass enters the feeder 8 for averaging and obtaining the composition necessary for fiber manufacture. The feeder 8 also has heating systems 7 to maintain a temperature range of fiber manufacture (1350 - 1450 °C) and a viscosity of 60 - 240 Pa/s.

Example of glass mass compositions and production process conditions of fiber manufacture are presented in Table 5 and 6.

Out of the feeder (8) the melt of glass mass is delivered by a stream feeding unit(9), through feeding units (10) to spinnerets (11). Elementary threads of the fiber (12) are pulled from the spinnerets, oiled by mechanisms (13), and reeled up onto bobbins (14).

Physico-mechanical properties of the basalt fibers are shown in Table 7.

As will be seen from the Table 7, the method and apparatus according to the invention make it possible to obtain high-strength, corrosion resistant, heat stable continuous fiber out of basalt rocks of numerous compositions, and to simplify the technology of its manufacture.

Sub B'1

Table 1

Composition number	Composition of rock base									
	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe	P
1.	4,567	0,232	11,537	32,932	2,426	1,428	12,771	0,240	33,968	-
2.	0,415	13,552	1,153	51,318	0,184	21,752	1,320	0,309	9,999	-
3.	6,573	0,358	20,340	60,648	4,873	2,088	1,506	0,001	2,689	0,326
4.	3,513	4,067	11,235	44,778	2,670	7,883	5,325	0,474	19,651	0,454
5.	5,744	0,465	19,541	56,221	4,503	3,924	2,889	0,180	5,642	0,890

Table 2

Composition number	Composition of large inclusions									
	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe	P
1.	5,420	0,352	26,824	54,104	0,461	10,875	0,330	0,061	1,552	0,00
2.	6,672	0,000	20,207	64,108	6,410	1,540	0,300	0,024	0,489	0,248
3.	1,425	13,499	2,304	50,003	0,166	19,882	1,917	0,216	10,279	0,871
4.	0,984	0,685	24,053	56,550	4,568	8,310	2,847	0,031	1,992	0,00
5.	4,160	1,859	17,890	58,470	4,688	5,817	0,497	0,245	6,378	0,00

Table 3

Composition number	Composition of small inclusions									
	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe	P
1.	5,775	0,413	18,112	63,813	8,139	1,459	0,132	0,000	2,156	0,000
2.	11,614	2,263	22,164	55,601	0,260	2,243	0,159	0,098	3,819	1,776
3.	0,422	1,364	0,817	0,830	0,086	0,214	23,541	1,226	71,502	0,000
4.	0,371	2,138	1,035	0,627	0,095	0,060	20,530	0,796	72,217	0,134
5.	0,727	12,683	1,364	49,475	0,187	20,085	2,023	0,250	13,121	0,087

Table 4

Composition number	Average composition of starting basalt									
	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe	P
1.	6,325	1,970	17,833	55,903	4,553	4,672	1,532	0,160	6,977	0,000
2.	5,058	7,932	14,127	46,164	2,320	4,697	1,343	0,396	16,461	1,512
3.	5,877	2,773	17,493	53,716	8,923	4,867	1,299	0,098	8,276	1,680
4.	4,587	3,187	17,660	52,501	3,927	5,515	1,701	0,155	8,541	1,953
5.	4,404	3,470	16,824	51,606	2,810	7,681	1,852	0,185	9,223	2,944

Table 5

Composition number	Glass mass composition for fibre pulling												
	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe	P	$\frac{Al_2O_3 + SiO_2}{CaO + MgO}$	$\frac{FeO}{Fe_2O_3}$	$\frac{2Al_2O_3 + SiO_2}{2Fe_2O_3 + FeO + CaO + MgO + K_2O + Na_2O}$
1.	2,00	10,58	11,82	50,42	0,52	8,84	1,04	8,18	12,25	0,21	3,2	3,34	2,0
2.	2,34	5,47	12,58	49,03	0,66	9,53	2,85	0,32	14,03	0,30	4,11	2,62	2,06
3.	3,88	4,65	16,75	50,61	1,0	9,07	1,81	0,18	10,26	0,40	4,9	0,54	2,37
4.	2,93	5,99	14,89	50,15	0,34	3,82	2,04	0,22	12,05	1,98	4,38	1,52	2,37
5.	4,75	3,54	15,33	49,66	3,10	6,56	2,84	0,21	12,05	1,98	6,44	1,62	2,39

Table 6

Composition number	Point of crystalization upon limit	Fibre diametre	Heat range of fibre manufacture	Viscosity range at T_{fmhr}
	T_{culp} °C	mcm	T_{fmhr} °C	Pa C
1.	1290	8,4 – 12	1360 – 1400	104 – 62
2.	1275	7,0 – 13	1380 – 1440	112 – 64
3.	1240	7,0 – 11	1370 – 1450	188 – 64
4.	1250	7,0 – 12	1350 – 1440	235 – 96
5.	1245	7,0 – 12	1350 - 1430	235 – 104

Table 7

Composition number	Strength and chemical resistance of fibre					
	Fibre diametre	Tensile strength	Chemical resistance in % after three-hour boiling			
	mcm	MPa	H_2O	NaOH		HCl
				0,5H	2H	2H
1.	10,2	2400	99,3	92,6	85,3	75,9
2.	10,0	3110	99,4	97,5	94,0	80,6
3.	9,0	2240	99,5	98,2	95,2	91,0
4.	9,5	3050	99,4	97,6	96,8	90,1
5.	9,5	3100	99,4	94,1	92,5	83,5